# Climate-induced warming imposes a threat to North European spring ecosystems

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-Background on climate change, groundwater and springs in Northern Europe

- Methods: spring datasets and approaches used

-Results on spring temperature trends

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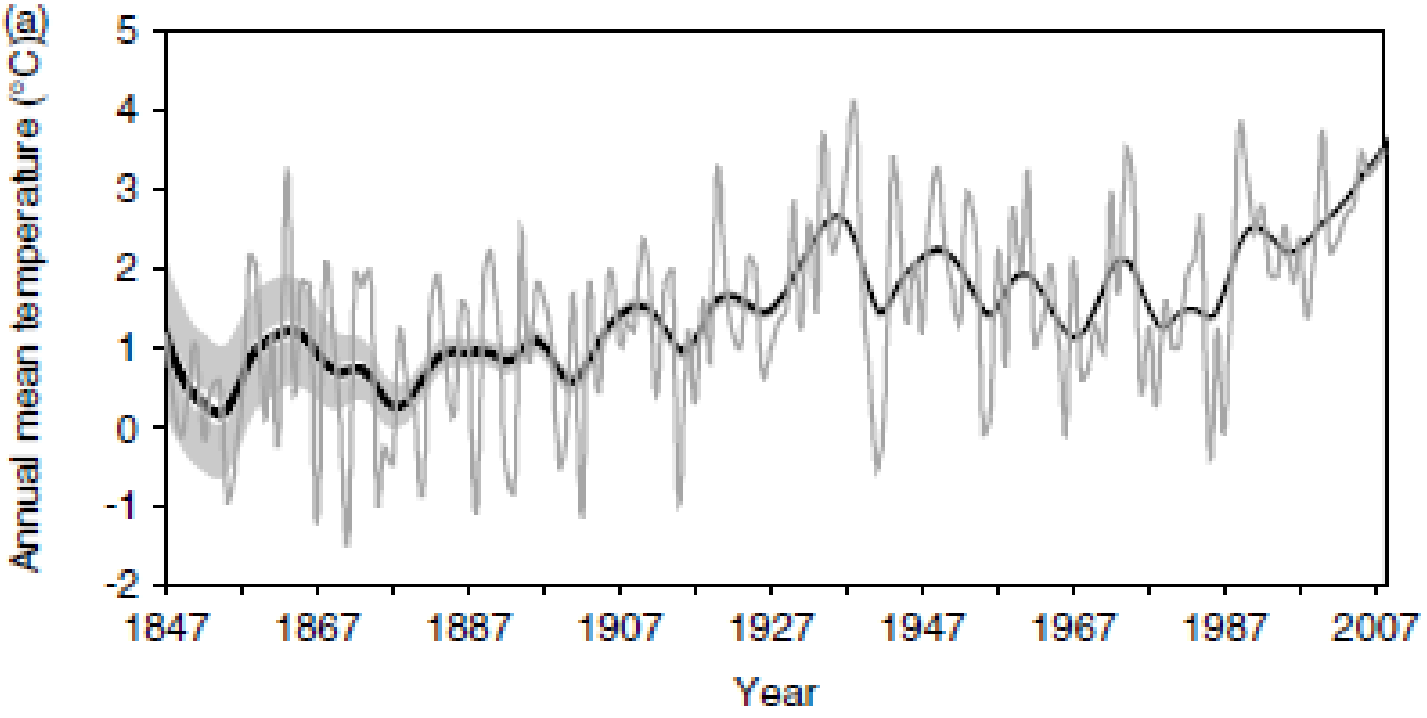
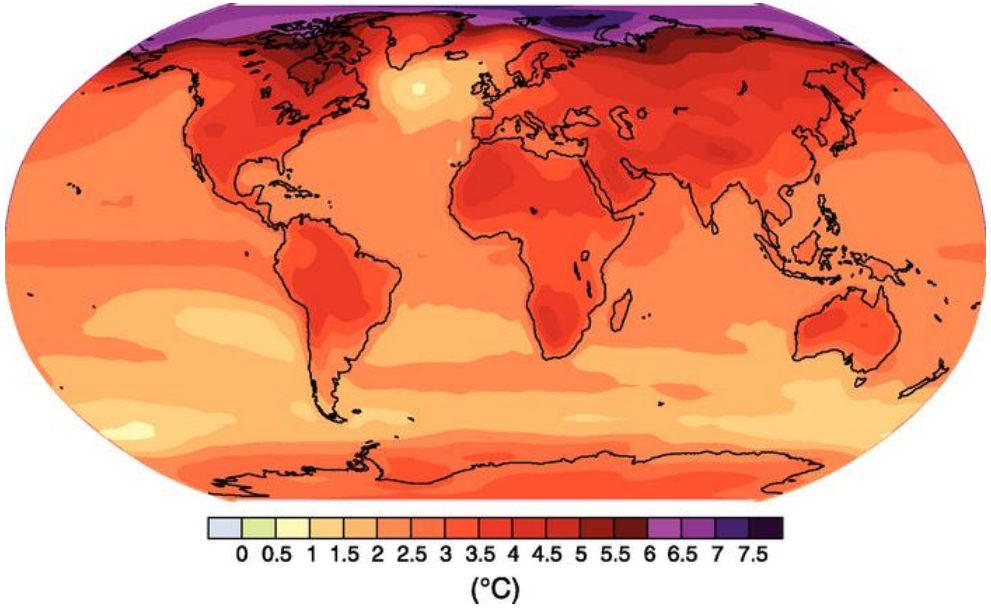
# Climate change

Temperature increase in Finland (south)



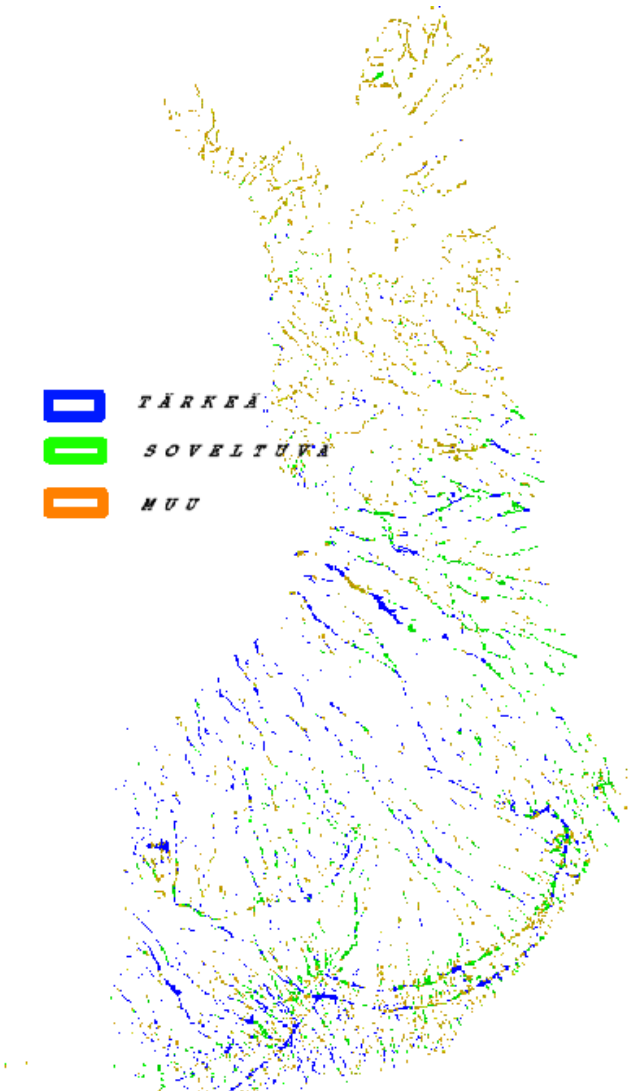

Global warming (change in temperature)

(from period 1980–1999 scenario a1B – to 2020-2029 and 2090-2099 )



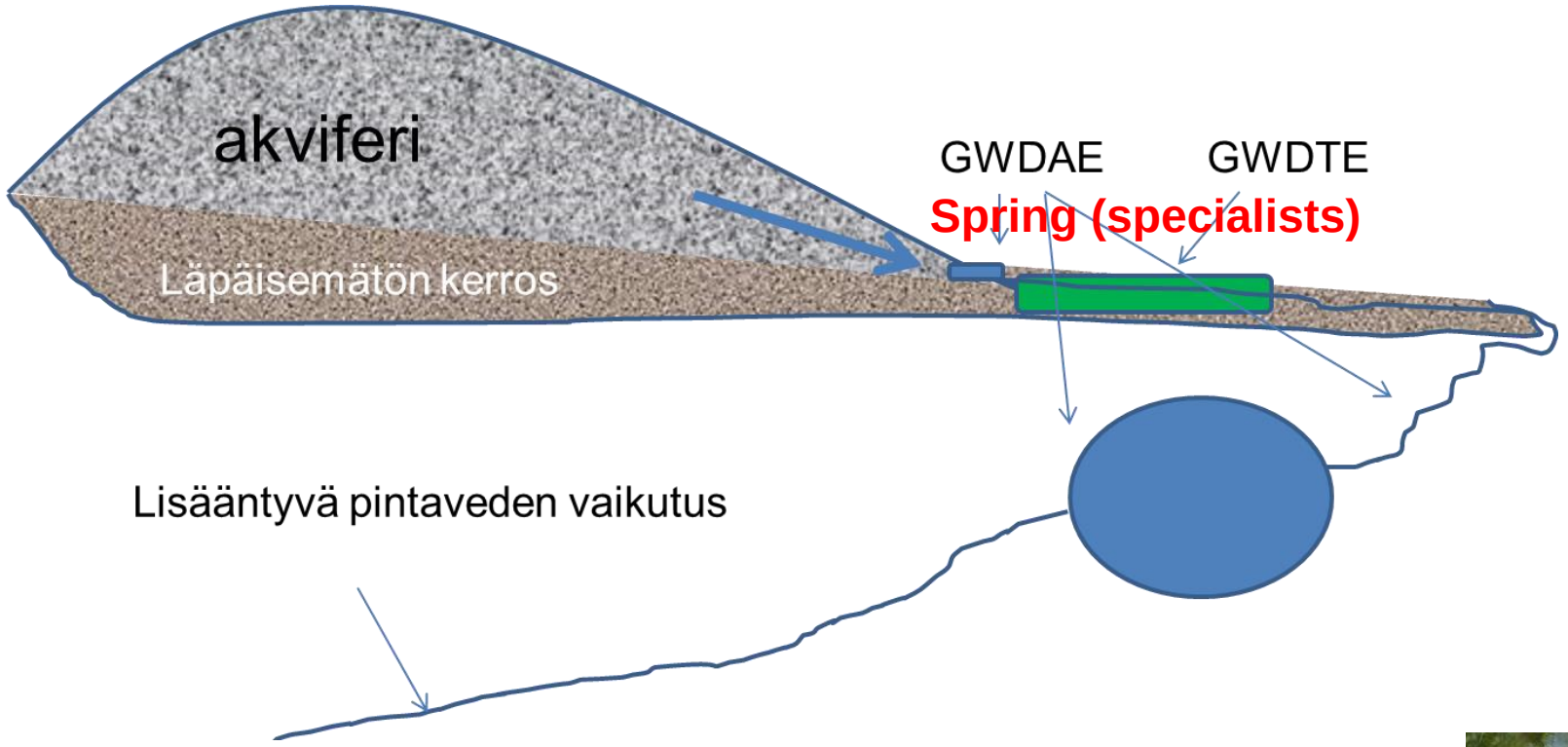
# Aquifers in Fenno-Scandia

- eskers
- riverine floodplain systems
- fractured rock
- karstic systems



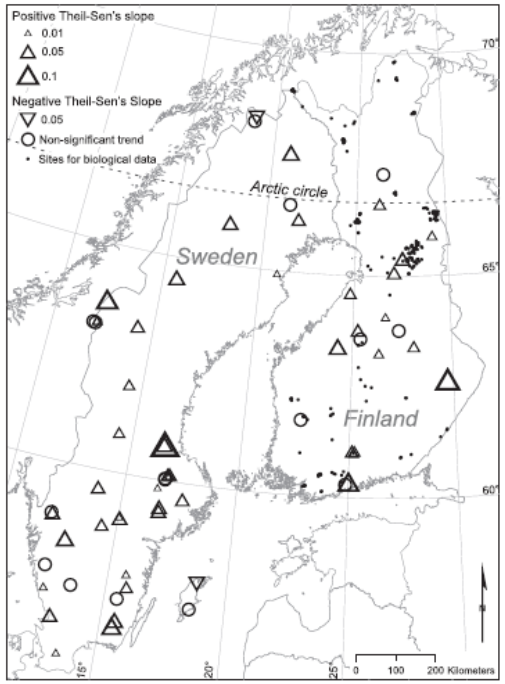

SYKE (map)

# Springs, water temperature, ecology




**Headwater systems (generalists)**

# Data on springs from Finland and Sweden




**Spring data**

- Finnish groundwater monitoring network
- Geological Survey of Finland
- Swedish groundwater monitoring program

**Data screened** to include datasets with record length more than 20 years and spring water temperture, **66 springs** (20 FIN, 46 SWE). Spring disharge form 44 sites and size of aquifer from 40 sites.

Mean record length **35 years** (max 45 years)

Springs **sampling frequency** 1-12 times annually

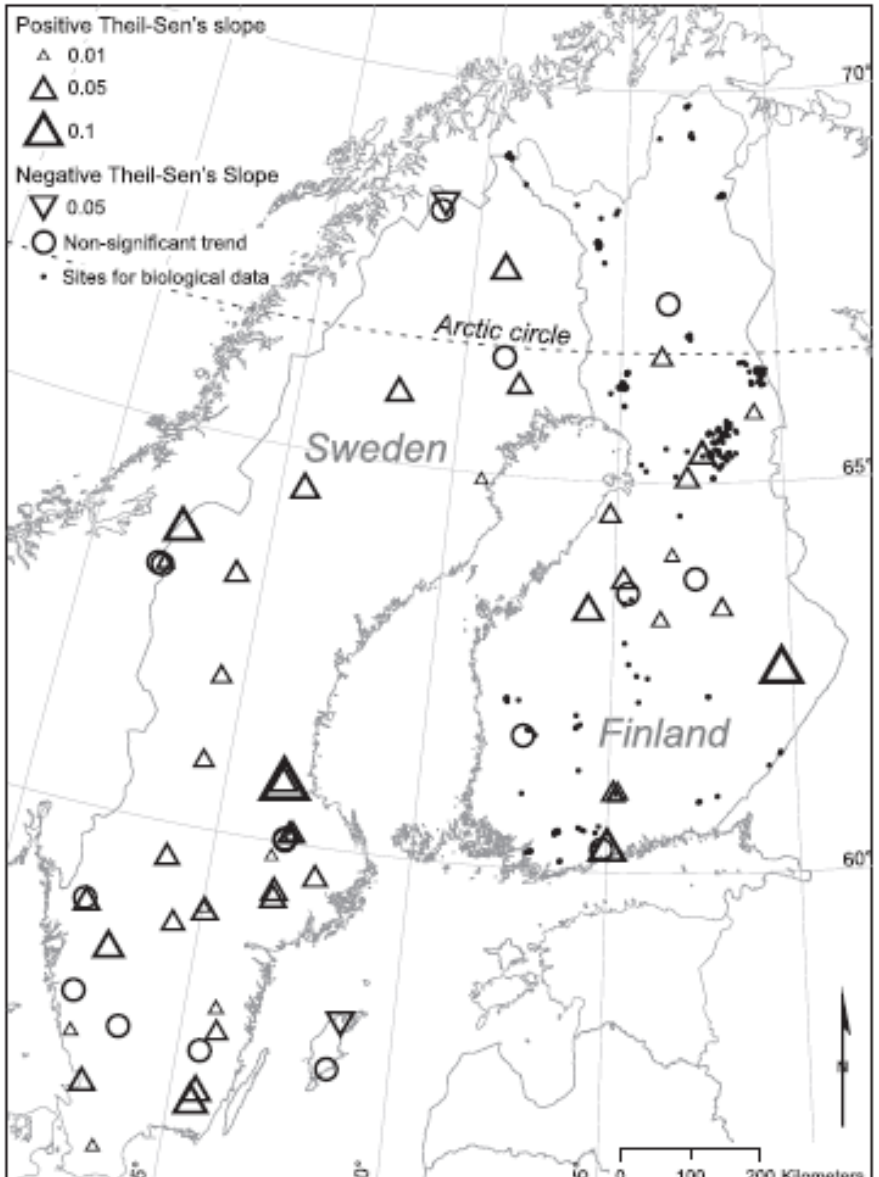
**Air temperature data** from SMHI and FMI (gridded data on 10x10 km and 4x4 km)

Biological data (aquatic bryophyte and benthic macroinvertebrates) from 208 Finnish springs with variable groundwater discharge

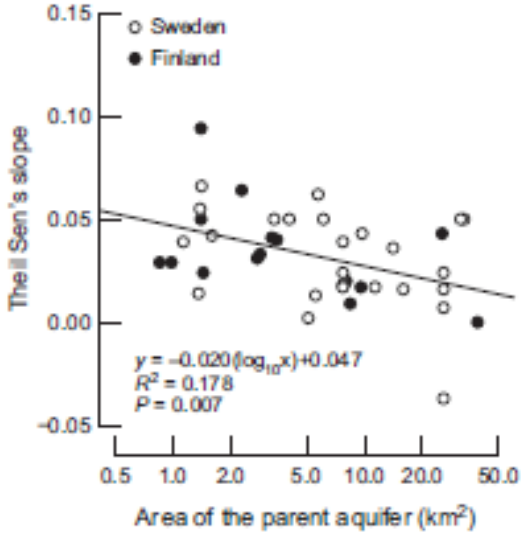
# Methods and approaches

- Spring temperature trend slopes (Theil-Sen’s method, Mann-Kendall test)
- Mean air and water temperature time series
- Multiple regression to relate annual spring water temperature to air temperature and radiative forcing
- Climate change air temperatures generated or 2015-2086 using results from CMIP5 project (SETUKLIM project by FMI) for RCP scenarisos RCP2.6, RCP6 and RCP8
- Species richness and composition dependency on water temperature modeled with ecological methods (statistical methods) GAM and RIVPACS

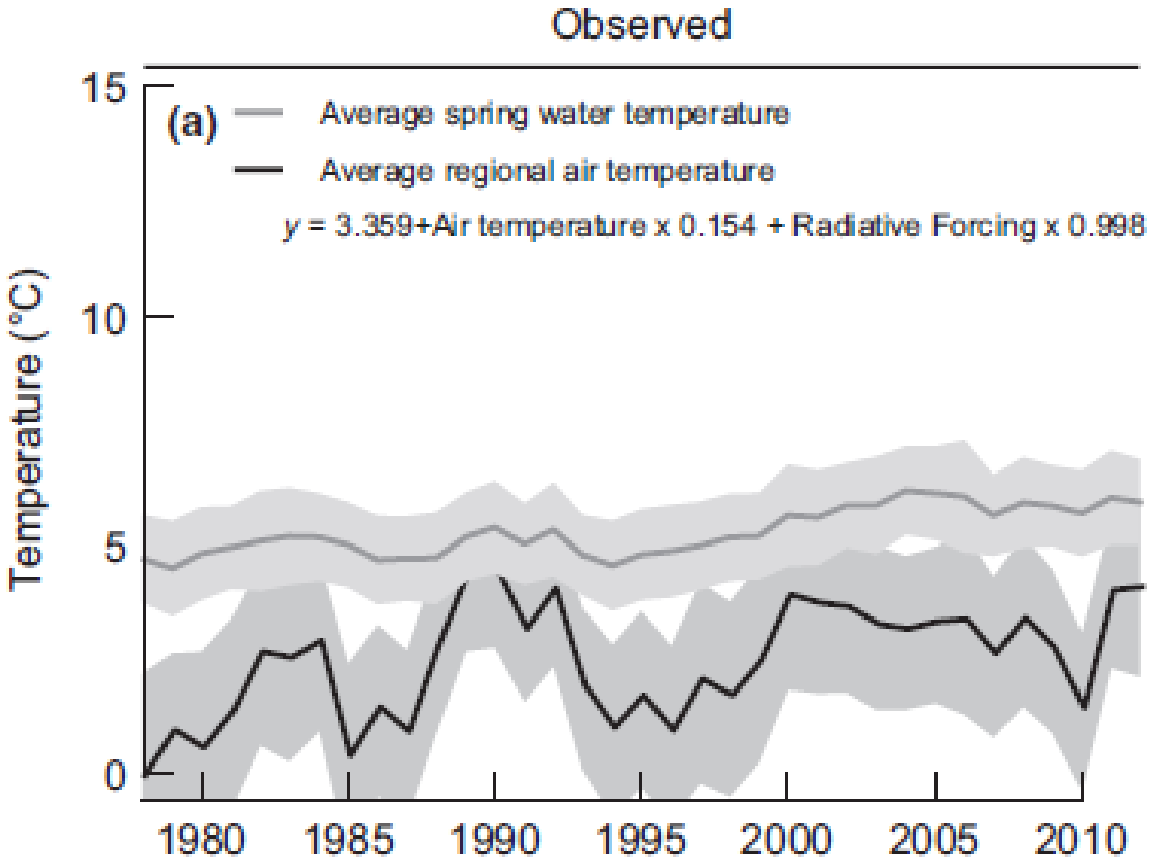
# Warming of springs




- 82 % show statistically significant warming trends
- Excpetion, larger springs in karstic settings in southern Sweden
- Spring discharge does not affect (low and high discharge springs are equally vulnerale to warming)
- Large aquifers, smaller warming rate

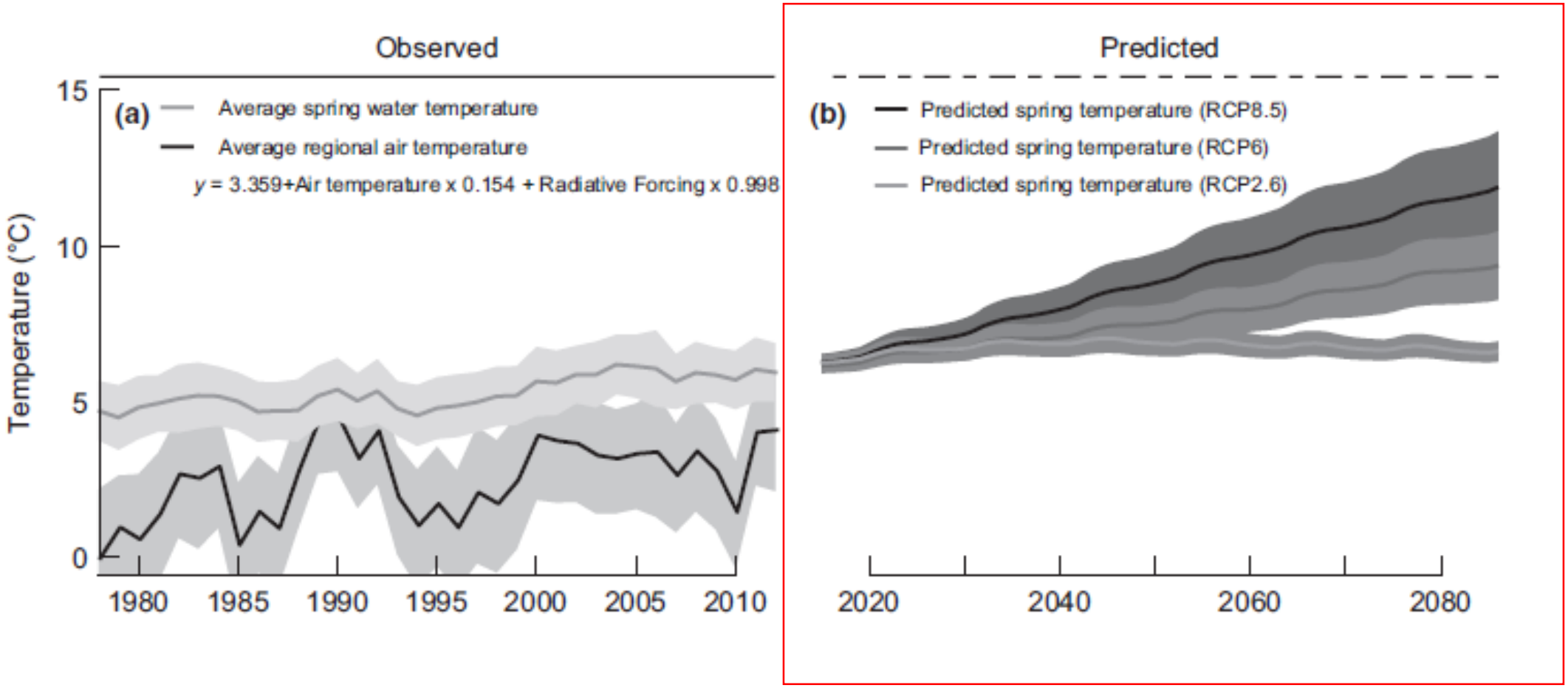


# Average spring water and air temperature

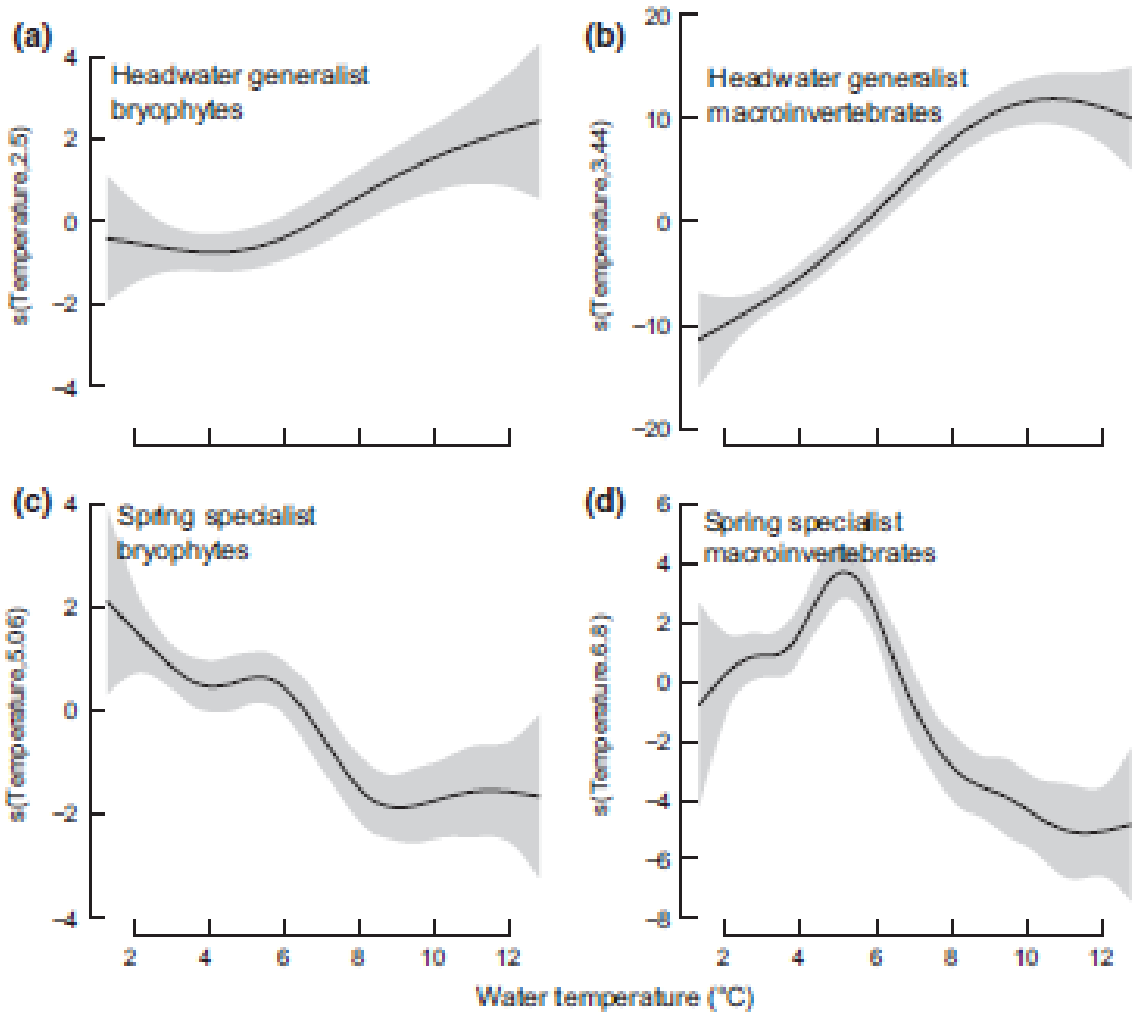



– **Water temperature increased from 4.70 C to 5.94 C, from 1978 to 2012**

# Climate change assessment



# Estimated effect of warming on species




**Headwater generalists - diversity increase**

**Spring specialists – diversity decrease**

# Conclusions

**Significant warming is expected in Northern Europe, and this can be a threat to groundwater dependent ecosystems**

**A large dataset on springs from Finland and Sweden was  compiled and used to asssess impacts of warming**

**in Sweden and Finland, springs show increasing warming trends**

**Warming effect spring ecosystems (biodiversity)**

**A significant warming reduce biodiversity of spring specialists**


Thank you for your attention!